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Rate of Microbial Contamination in Operation Theatres of Allied Hospital Faisalabad Before and After Fumigation

Muhammad Ans Ahmar[1*], Hina Javaid[1], Adeel Shahid[2], Hasnain Raza[3], Natasha Nazir[4]

1Department of Medical Laboratory Technology, Riphah International University, Faisalabad, Pakistan

2University Institute of Medical Laboratory Technology, University of Lahore, Lahore, Pakistan

3Department of Pathology, Allama Iqbal Teaching Hospital DG khan, DG Khan, Pakistan

4Department of Biological Sciences, National University of Medical Sciences, Rawalpindi, Pakistan

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***Corresponding author Email:** ahmarmashori@gmail.com

Abstract: An operation theatre serves as a critical facility within a hospital where surgical procedures are conducted under controlled conditions. It is imperative that this environment maintains stringent sterility and pathogen-free conditions to mitigate the risk of nosocomial infections among patients undergoing treatment. Despite meticulous sterilization protocols and stringent measures in place, the heightened microbial presence within the operation theatre can potentially lead to surgical site infections and complications, transcending all protective and fumigation efforts. Such contamination within the operation theatre poses a significant risk, often resulting in severe surgical site infections which can compromise patient outcomes. A quasi-experimental study was performed by collecting samples from operation theatres (OTs) of Allied hospital Faisalabad. Samples were taken before and after fumigation. Sampling includes swabbing from surfaces of sites of operation theatres. Sterile cotton swabs moistened with normal saline were taken to operation theatres and rolled on the surfaces of operation tables, instrument trolleys, walls, OT lights, suction machines and anesthesia machines which are then packed and sealed and further processing performed in laboratory. A total of 96 swabs, 32 (33.33%) swabs were growth positive before fumigation and 13 (13.54%) after fumigation. Total reduction rate after fumigation was 19 (59.38%). Fumigation is effective but it is toxic. As the methodology involves use of toxic vapors of formalin and requires prolonged closure of the theatres up to 72 hours, it is difficult to perform on a regular and frequent basis. It is suggested that to improve the efficacy of the whole process, formaldehyde fumigation be replaced with newer methods i.e. fogging with hydrogen peracetic acid vapors.

Keywords: *Operation theatre, Fumigation, Nosocomial Infections, Formalin*

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1. Introduction

Microbial contamination in the operating theatre is a major problem facing patient safety and overall quality of health service delivery. Operating rooms are ideal environments for various microbes, including bacteria, viruses, and fungi (Kamran et al., 2022). Microbes in the theatres can lead to healthcare associated infections and surgical site infections. Understanding the mechanism of microbial contamination in the operating theatre and the immediate aftermath of theater fumigation is vital in creating a safe surgical environment. Several intrinsic and extrinsic factors contribute to the high microbial load in the operating room before fumigation (Anwar et al., 2022). The source of contamination includes the patients, healthcare personnel, surgical equipment, and environmental contamination at the time of fumigation (Umaiyal et al., 2020). Patients, as they often do, carry a wide range of pathogenic bacteria and fungi. Despite following strict aseptic technique, healthcare personnel may be a source of blood-borne and airborne contaminants (Humayun et al., 2019). The aseptic techniques may fail to eliminate all microbes, and ones, they have resistant bacteria are introduced to the theatre environment. Surgical equipment, if not well sterilized, this will provide a conducive environment for microbial growth before the surgery (Esakki et al., 2023).

Additionally, poor cleaning mechanisms and theatre surface flooding contribute to microbial contamination (Raksha, 2019). The surrounding may be dirty, especially when bloody surgery is performed. Also, organic substances such as pus, blood, tissue fluids, and other body secretions are allowed to dry on the surface, offering a cosy place for microbial growth (Noreen et al., 2020). Poor air circulation will further lead to air-borne contamination of the theatre (Karigoudar et al., 2020). Therefore, running some tests using various tools to compare these factors in same hospital theaters would provide reliable data basing on the qualitative data (Naumeri et al., 2020).

Fumigation, as a distinct disinfection technique, is instrumental in lowering microbial contamination in the operating theatre. Numerous fumigants with a broad antimicrobial spectrum are used to target both surface-bound and airborne microbes (Maisuriya et al., 2023). Notable among the fumigants is hydrogen peroxide vapor, ozone, formaldehyde, and chlorine dioxide. Common fumigants are selected based on efficacy, safety, and penetration ability into hard-to-reach areas within the theatre setting (Bali, 2021). For fumigation to be successful, the theatre must be sealed to keep the fumigant contained and set the ventilation mode to ensure uniform distribution (Bhatwalkar et al., 2019). A strict safety protocol ensures that theatre personnel is not at risk of exposure to the harmful fumigants. Additionally, the timing and fumigant concentration are critical factors to consider effecting optimal disinfection without compromising safety. After the fumigation process, microbial contamination is proportionally monitored, and defined analysis and tests are conducted to assess the effectiveness of the process (Yimer & Alemu, 2022). This includes surface swabs, air sampling, and microbiological assays to determine whether microbial counts have been substantially reduced compared to pre-fumigation levels. The result reflects a much cleaner theatre setting ideal for conducting safer surgery (Ndu et al., 2022). The outcome of a disinfection process such as fumigation is instrumental in-patient safeties. It minimizes the microbial count in the theatre setting, hence reducing the risks of developing SSI and HAI. Such desirable surgical outcomes are necessary for a patient's recovery process in the postoperative phase and to the general quality of healthcare (Kenimak, 2019). To ensure this state, healthcare facilities have put in place quality assurance strategies involving audits, inspection tests and compliance to ensure the maintenance of a sterile environment (Zhao et al., 2022).

There is a dire need to maintain optimal levels of infection control and patient safety in the healthcare setting. Understanding the extent to which fumigation is effective in reducing microbial contamination will help the hospital to prevent healthcare-associated infections, including SSIs. To achieve this goal, this study assessed the microbial load in the operation theatre before and after fumigation to provide the hospital with evidence-based recommendations on enhancing its current fumigation strategy. As a result, the hospital will improve its hygiene conditions, minimize the risk of infections, and boost patients' overall hospital experience.

2. Material & Methodology

Our study design was a quasi-experimental that was done in multiple operation theatres at Allied Hospital Faisalabad to identify the microbial contamination rate prior to and post-fumigation. Ninety-six samples comprising forty-eight pre-fumigation and forty-eight post-fumigations were collected from various areas and equipment in the OTs. A sterile culture swap was used to collect the samples which were cultured in diverse media cultures including blood agar, MacConkey agar, and nutrient agar for analysis (Baskaran et al., 2019). Gram staining and biochemical tests were carried out for investigating bacterial growth and species identification (Singh et al., 2021). Gram staining was crucial in the identification of the morphology of the bacteria while biochemical tests such as the oxidase test, coagulase test, and catalase test were based on species identifications that included unique biochemical reactions (Mathur, 2019). The results of the study would be essential in determining whether there was any relationship between the microbial contamination rate, and different OTs, and this would provide important information on the infection control practices in a hospital.

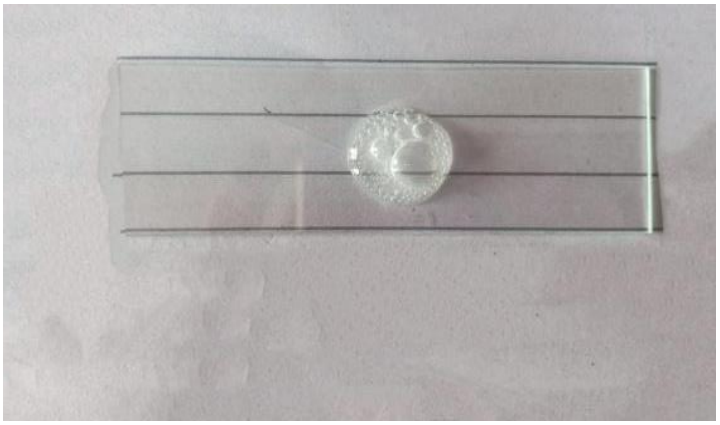

Figure 1: Catalase test

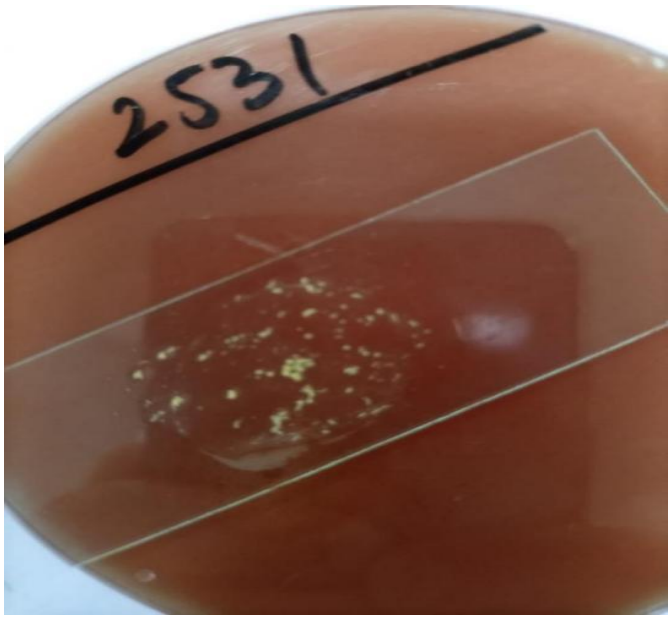

Figure 2: Coagulase test

Figure 3: Oxidase test

Figure 4: *Pseudomonas aeruginosa*

Figure 5: *Staphylococcus species*

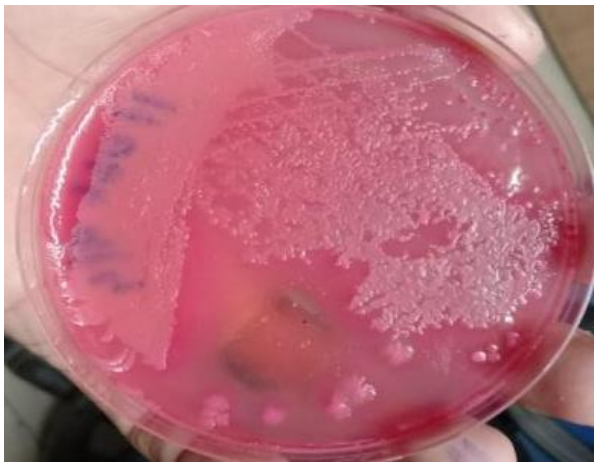

Figure 6: *E. coli*

Figure 7: Staphylococcus Species

3. Results

11 Operation theatres of Allied Hospital were included in this study. Our study included Obstetrics and Gynecology four rooms, Emergency operation theatres two rooms each and one room each for Neurology, Orthopedic, ENT and Eye operation theatres.

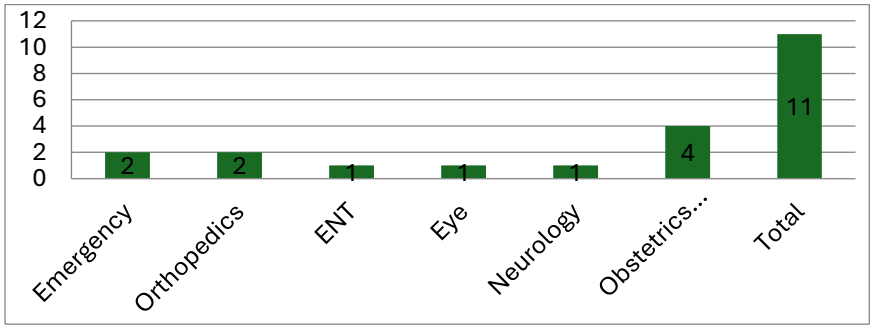

Figure 8: OT Rooms

A total of 96 samples (swabs) were processed. Out of 96 samples, 48 samples were processed before fumigation and 48 were processed after fumigation (total 16 samples from each operation theatre). Growth in individual operation theatre was variably seen and is given with its percentages**.** From a total of 96 swabs, 32 (33.33%) swabs were growth positive before fumigation and 13 (13.54%) after fumigation. Total reduction rate after fumigation was 19 (59.38%). Before fumigation, the Neurology OT exhibited the highest microbial contamination rate at 43.75%, while the Orthopedics and Eye OTs showed the lowest rate at 25%. Following fumigation, the microbial contamination rate decreased significantly, with the ENT and Orthopedic OTs showing a maximum reduction to 18.75%. Conversely, the Obstetrics and Gynecology OTs displayed the lowest post-fumigation contamination rate at 6.25%. The Emergency OT witnessed the most substantial reduction in microbial contamination post-fumigation, with a rate of 66.67%, whereas the Orthopedics OT exhibited the least reduction at 25%.

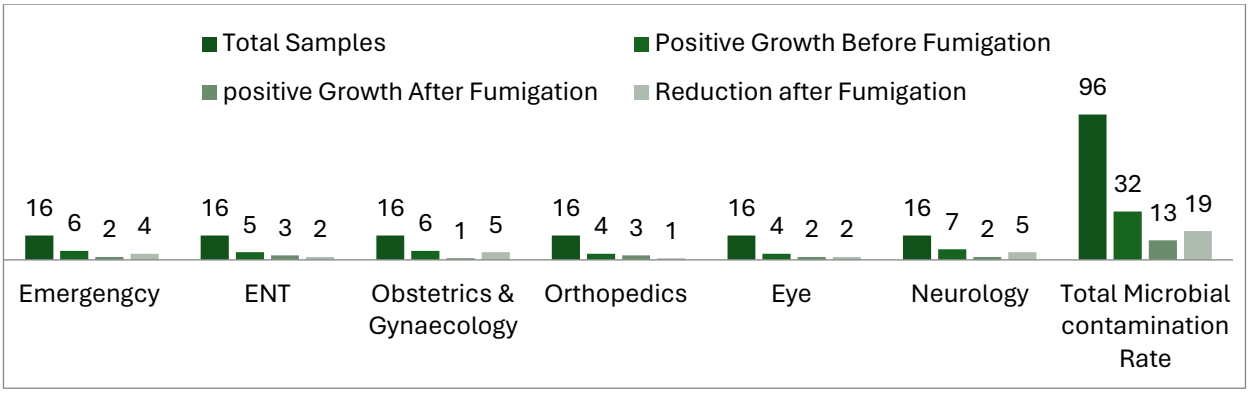

Figure 9: Microbial Contamination in different OTs before and after fumigation

To ensure uniform collection, swabs were taken from 6 fixed sites from each operation theatre. Thus overall, 16 swabs were collected from OT tables, instrument trolleys, walls, suction machines, anesthesia machines and OT lights, making a total of 96 swabs from 11 operation theatres. The positive microbial growth on OT table, instrument trolley, walls, suction machine, anesthesia machines and OT light. Maximum microbial growth before disinfection and fumigation was seen on Anesthesia machines 7 (43.75%) and minimum growth on Instrument trolleys and OT Lights 4 (25%). Maximum contamination after disinfection and fumigation was seen on suction machine and OT Lights 3 (18.75%) and minimum growth on OT tables 1 (6.25%). The maximum reduction rate of microbial contamination after fumigation was seen on OT tables 5 (83.33%) and minimum was seen on OT lights 1 (25%).

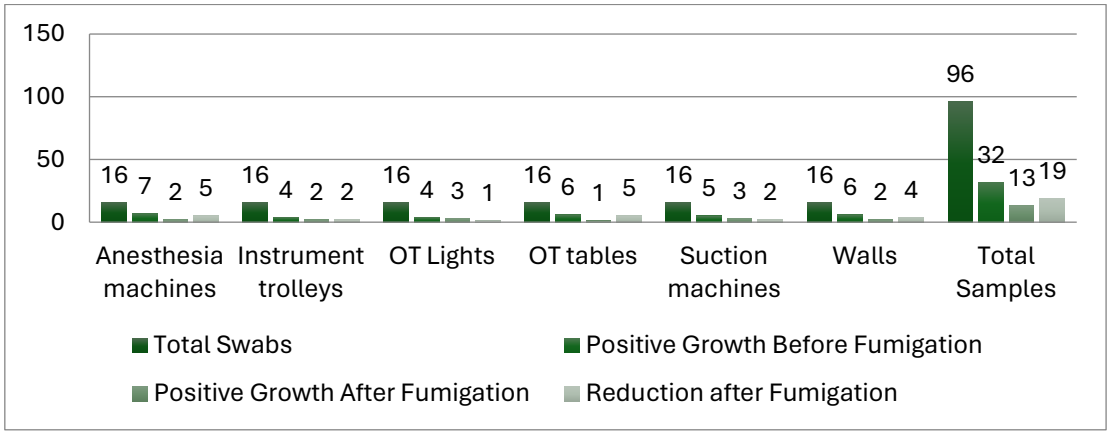

Figure 10: Sample collected from different instruments.

The various microbes isolated before and after fumigation and disinfection of Operation theatres are given in Table (5). The most isolated microbes before disinfection fumigation were *Staphylococcus species* 11, followed by *Bacillus* species 9 while the least isolated microbes were from *E. coli* family 2. After fumigation, the most isolated microbe was *Staphylococcus species* and fungus 4 followed by *Bacillus species* 3 and *E. coli* bacteria were absent. Reduction in growth of *Staphylococcus species*, *Pseudomonas aeruginosa*, *Bacillus* species, *E. coli* and Fungus after fumigation were calculated to be 7, 3, 6, 2 and 1 respectively.

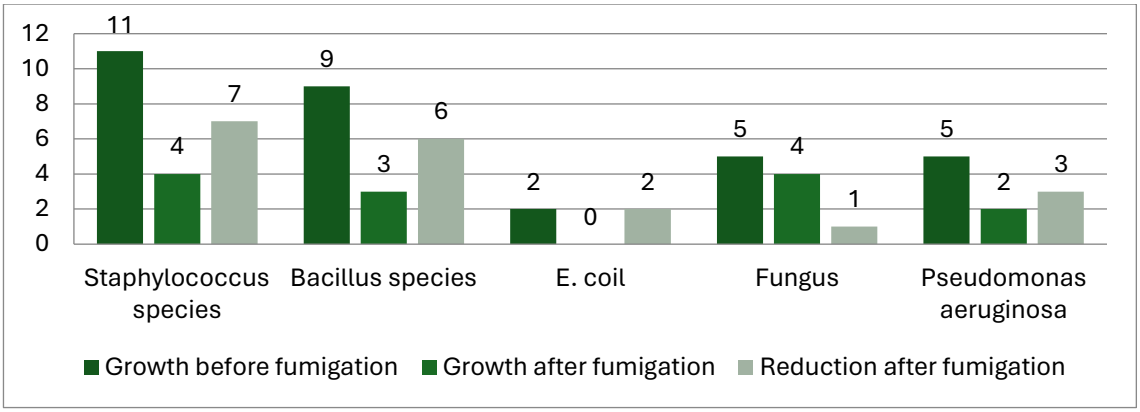

Figure 11: Presence of various microbes before and after fumigation in OT

Following incubation for 24 hours, growth was observed on various culture plates, prompting differentiation using the Gram staining technique. Gram staining serves to distinguish between gram-positive and gram-negative bacteria based on cell wall characteristics. Subsequent microscopic examination at 100x magnification confirmed the gram staining results. Further differentiation was achieved through biochemical tests, specifically catalase and coagulase assays. These tests aid in characterizing bacterial species based on their enzymatic and clotting properties, respectively, contributing to comprehensive bacterial identification.

4. Discussion

Microbial prevalence in operation theatres has been a key factor for dissemination of the infections acquired in the hospitals, termed as the hospital-acquired infections. The contaminated environment of the operation theatres can be a major element for spread of infection in patients as well as in health care workers. It is the long-time exposure to risk factors, especially pathogenic bacteria that can make the situation worse. It is sterilization that eliminates the microorganisms to attain an aseptic environment. On this context microbial testing of the surfaces and equipment's to detect the microbial flora is very important.

Controlling the presence and transfer the airborne pathogens in health care settings is very important not only for the patient's safety but also for the hospital. With improper sterilization of the operation theatres, a dramatic increase in infections at the surgical sites is expected that could lead to poor extrapolative results in post-surgery conditions. Hospital and operation theatre environment act as a reservoir for pathogens that could spread anytime to patients, healthcare workers and visitors and some of these are *E. coli, S. aureus, K. pneumoniae*, *P. aeruginosa*, *Acinetobacter baumannii* and other microbes that are life threatening for patient. Disinfectants are marked to be the key factor for control of spread of pathogens in hospital ensuring a microorganism's free zone leading to safe environment. For the initial confirmation of the samples, the samples were first cultured on nutrient agar followed by MacConkey agar. Further processing and confirmation of the isolates by microscopy for observation of the microscopic characteristics was made by Gram staining method that revealed purple stained cocci in the form of cluster and pink rods in the form of chains. The presence of *S. aureus, K. pneumonia, P. aeruginosa, E. coli* confirmed by different biochemical tests.

For the initial confirmation of the samples, the samples were first cultured on nutrient agar followed by MacConkey agar and blood agar. Further processing and confirmation of the isolates was done by microscopy. For observation of the microscopic characteristics, Gram staining method revealed gram positive and gram-negative bacteria. The presence of *Staphylococcus species, Bacillus species, P. aeruginosa* and *E. coli* confirmed by different biochemical tests. The result of current study showed that out of 48 samples that were collected before fumigation from Allied Hospital Faisalabad; the frequency of positivity was 32 and highest prevalence was observed for *Staphylococcus species* and lowest prevalence was observed in *E. coli.* While 48 samples were collected after fumigation from Allied Hospital

Faisalabad; the frequency of positivity was 13 and the highest prevalence was found for *Staphylococcus species* and lowest prevalence was observed in *E. coli*.

A similar study was designed by Matinyi et al. (2018). They isolated overall 14 different microbes were isolated with *Bacillus* spp. (17.5%), *Aspergillus* spp. (15.8%), and *Pseudomonas spp.* (23.9%), being the most common contaminants. Other isolates included *Rhizopus* spp., *Enterococcus* spp. and Coagulase Negative *Staphylococcus* isolates especially from settle plates. A similar study was designed by Mutib et al. (2021). A total of 334 different microbes were observed with *Staphylococcus epidermidis* (171), *S. aureus* (111), *Bacillus species* (118), *P. aeruginosa* (24), *Klebsiella species* (92), *Escherichia coli* (23), and *Enterobacter species* (82). A similar study was designed by (Tavhare & Lakhani, 2023). A total of 32 samples were taken (n =32), 11 (34.3%) specimens were positive before fumigation. 7(21.9%) were positive after fumigation. A similar study was designed by (Vanlalruati et al., 2023). A total of 967 samples were examined, 725 (70%) gave positive bacterial growth. Out of 725 microbes, *S. aureus* was 236, *P. aeruginosa* were 174, and *E. coli* were 112.

Microbial contamination from the samples collected from operation theatres has been a serious risk to the patients' lives as in many of the surgical cases immunosuppressant are advised for the patients and these microorganisms in immunosuppressive conditions could be a serious life-threatening issue, however, fumigation has shown very positive results, so it is recommended to use this technique for microbial disinfection. Microbial assessment of air and surfaces of the operation theatre must be performed routinely in order to minimize the microbial prevalence and spread and ensuring the safety of the patients, healthcare workers and visitors.

5. Conclusion

The decontamination of the operating room is very important as it is the most critical step that leads to life threatening outcomes like transfer of nosocomial infections for patients. As bacterial contamination rate is higher in Operation theaters and cause different diseases preoperative, intraoperative, and postoperative through different microbes that are present in operating room some of these are *Staphylococcus species*, *Bacillus species*, *P. aeruginosa, E. coli,* and other microbes which is life threatening for patients. These microbes cause serious infection to post operatively and become the major source of contamination. Notable reduction in microbial growth in operation theatres was seen after thorough disinfection and fumigation which shows it is an effective procedure of sterilization. Fumigation done on a regular basis reduces the contamination in operation theatres, therefore reducing the chance of acquiring nosocomial infections in admitted patients. However, although fumigation is effective, it is toxic. As the methodology involves use of toxic vapors of formalin and requires prolonged closure of the theatres for up to 72 hours, it is difficult to perform on a regular and frequent basis. It is suggested that to improve the efficacy of the whole process, formaldehyde fumigation be replaced with newer methods i.e. fogging with hydrogen peracetic acid vapors.

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